TIEE

Teaching Issues and Experiments in Ecology - Volume 6, February 2009

EXPERIMENTS

Biodiversity Responses across a Gradient of Human Influence

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A picture of a forest plot from the UWM Field Station, illustrating the low human influence site in the study, and a picture of downtown Montreal, illustrating high human influence (note that Montreal is used for descriptive purposes here and was not part of the study). Pictures by C.A. Lepczyk.

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CITATION:
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STUDENT PRODUCTS

Students are assessed on: 1) field notebook; 2) poster presentation; and, 3) draft and final paper written in format of *Ecology*.

SETTING

The labs are carried out along gradients from rural (or pristine) sites to urban (city center or human-dominated) sites and can be sampled in a variety of orders. The labs can be conducted at any season as long as the instructor is aware of what species can be identified in the field at a given time of year. However, the lab works a bit easier during spring through autumn. The number of different points along the gradient to sample should ideally be at least five, in order to have enough data points to provide support for the hypotheses being tested. Data processing and analyses take place in the lab.

COURSE CONTEXT

This lab was taught in the General Ecology (Biological Sciences 310) course in the Biological Sciences Department at the University of Wisconsin-Milwaukee. The course contained 80 students, who were divided into sections of 20 for three hour laboratories once per week. Within each lab section the students were divided into groups of five students each based upon a random draw of four different colored suckers, resulting in 16 groups across all laboratory sections. All students participated in the lab. Labs were run by the instructor with one graduate student teaching assistant that was competent in identifying species of at least one taxonomic group (e.g., trees, birds, small mammals).

INSTITUTION

I teach at a large research institution.

TRANSFERABILITY

This lab can be easily altered to add more material, labs, or ideas, thus creating a more in-depth experience for advanced students. Similarly, the lab can be reduced to a project that takes only several sessions, if simply trying to look at the relationship on the gradient and the instructor synthesizes the data. Furthermore, the lab can be used to investigate relationships along a gradient and not as a strict test of three hypotheses. The lab can easily be transferred to non-majors classes and any location where a gradient is in close proximity to an institution. Students with disabilities can participate throughout, but may have more challenges in field settings, depending upon the nature of a given location. Finally, the lab can be run in a pre-college or introductory division course if the instructor takes a more active role in modifying or assisting with the lab or it is reduced in scope.

ACKNOWLEDGEMENTS

The origin of this laboratory arose when I held a one year Visiting Assistant Professorship at the University of Wisconsin-Milwaukee (UWM) from 2005-2006 in which I taught General Ecology 310. During the previous decade the laboratory component of the ecology course had been revamped with support from the National Science Foundation to focus on testing one general ecological relationship or theory. Prior to my arrival the general relationship investigated had always been the River Continuum Concept (RCC). As an ecologist with a focus on landscape ecology and applied questions, I was charged with reinvigorating the lab to a wider audience that had an applied focus (which was important given the urban nature of the campus and student body). The primary individual responsible for developing the idea of a single semester long laboratory at UWM, and mentor for my development of this current lab, was Timothy Ehlingher, an Associate Professor in the Biological Sciences Department at UWM. In addition, my inspiration for this laboratory and its various components were my two undergraduate mentors from Hope College, Kathy Winnett-Murray and K. Greg Murray. I would also like to thank Neil Beckman and Brianna McDowell who served as inspirational teaching assistants for the first running of this laboratory. Finally, Christopher Beck and two anonymous reviewers provided a number of valuable thoughts that helped to improve the clarity of the laboratory.

SYNOPSIS OF THE EXPERIMENT

Principal Ecological Question Addressed

How do species, communities, and habitats change over the landscape from areas of little or no human influence to areas with high human influence?

What Happens

To investigate how species, communities, and habitats change over the rural-urban (or pristine to human-dominated) gradient students conduct a series of biological inventories, field measurements, taxonomic keying out, natural history classifications, landscape classifications, statistical analyses, and a literature review. Each laboratory session will be geared towards one or several of these aspects, with groups of five students working together. Biological inventories and field measurements will take place outdoors, while the remaining aspects take place in the laboratory.

During the first week, lab sections take a walking tour of the local ecosystem (generally urban or human-influenced if near a college or university) to acquaint students with ecological relationships, plants, animals, and the environment in which they live. In the second week the semester-long project guidelines are handed out to students and gone over during lab. The remainder of the lab is dedicated to literature, literature review, and using database search tools in a computer laboratory. During the next four to six weeks (weeks 2-8), students visit different plots along the gradient to conduct biological inventories and record environmental aspects that they can use to assess a human influence gradient. Over the course of this six week period (e.g., when inclement weather is present) a lab session is devoted to data entry, quality control and assurance (QA/QC), metadata (information about data or data about data), and data synthesis in a computer lab. Students enter the field data, add in natural history information, including scientific nomenclature, body mass (animals) or biomass (trees), native or exotic/invasive, etc. that they have obtained through field guides or reputable on-line documents. Finally, students have their field notebooks evaluated after the second field visit. In the ninth and tenth weeks, the laboratory time is devoted to a basic statistical lab (which can also be broken out for a separate exercise and graded if desired) and graphical interpretations. Statistical information includes a short lecture on what the statistics are testing, why they are useful, and how to interpret them. Depending upon the institution and time a third week and component also can be included on integrating GIS into the exercise. In the eleventh through thirteenth weeks, lab sessions are devoted to data synthesis and analysis, poster presentations and report preparation. Finally, in week 14 each groups of students gives an oral presentations of their posters, and have one final week to complete their final lab paper.

Experiment Objectives

The major objectives of the semester project are to:

1. Investigate how species, communities, and habitats change with varying degrees of human influence

2. Learn how to conduct field surveys (i.e., biological monitoring) and keep field notebooks

3. Use different tools and methods common in ecological research

4. Integrate field data with information from field guides and the literature

5. Analyze and describe the data you and others have collected, including the use of metadata

6. Synthesize the results, comparing them with what other scientists have previously found using gradients measured with the same human influence metrics and with different metrics

7. Present the research findings using standard scientific approaches

Equipment/ Logistics Required

The primary pieces of field equipment vary depending upon the taxa investigated (e.g., binoculars for birds, Sherman traps for small mammals, pit traps for arthropods), which can be decided by the instructor.

For the UWM laboratory, birds and trees were the species inventoried. Based upon this taxonomic grouping, the following equipment was needed:

1. Binoculars
2. Field tape measures
3. Flagging tape
4. Field guides for birds and trees
5. Taxonomic keys
6. Thermometers
7. Computer lab equipped with:
    a. MS Excel (or other comparable spreadsheet program)
    b. Statistical software capable of regression, *t*-tests, and ANOVA
    c. Software for poster presentations (e.g., MS PowerPoint)
    d. GIS software, if landscape analysis is desired (optional component)
8. Access to a library where gray literature (i.e. government reports, theses, etc.) can be found and access to a literature database search engine (e.g., ISI Web of Science)

In addition to the equipment, the field labs will need to sample various points along a gradient that are predetermined by the instructor. This will require scouting out possible locations ahead of time and then arranging for the class to walk, drive or meet at the field sites. Logistically, the different field sites could be close together or far apart, depending upon the location where the course is taught. If substantial time will be required to reach a rural or pristine location, labs also can be run during a weekend day. By having a weekend option the class an also sample several locations all in one day.

Summary of What is Due

The overall lab project is graded based on three separate components: 1) the field notebook, 2) a poster, and 3) a research paper. In addition, I used a separate literature review exercise that allowed students to get exposure to the library, and finding peer-reviewed articles on ISI Web of Science. This literature review exercise can be included as part of the entire lab or as a separate exercise.

Graded Components

Field Notebook. One of the keys in learning to do science is understanding how data are recorded (more in lab on this topic) and why it is important. You are required to keep a waterproof field notebook (e.g., Rite in the Rain) of your time in the labs. The notebook will be graded twice in order to assess your understanding and progress. Details to be included in the notebook include: a table of contents, page numbers, location of the plots where data is collected, environmental data (e.g., temperature, time of day, sky), and biological inventory information following the examples given in Field Lab 1. The field notebook is worth 25 points, with 10 possible points allocated for the first round of grading and 15 possible points for the second round of grading.

Poster Presentation. Posters are visual mechanisms that allow a quick and easy means to describe the work or knowledge that you have to share. In conjunction with your final lab research report, you and members of your lab group will prepare a poster presentation of your lab research project. This poster will be the responsibility of the entire group and the grade will reflect the input of all members. There are a number of styles and formats for designing a poster and they will be discussed in detail in coming weeks. The research poster portion of the project will be worth 50 points and will be graded independently of the research paper. The total points awarded to each student

student.

Research Paper. One of the ways that ecologists share knowledge is through publishing peer-reviewed journal articles. The research paper will follow the format of a standard scientific article such as the journal *Ecology*, the guidelines for which I have included on the following pages. Specifically, the paper will include a title, abstract, introduction, methods, results, discussion, and literature cited. Draft sections of the Introduction and Methods are required and will be evaluated for feedback to students.

The research paper will be done individually and should reflect your own work. Thus, while you can work with members of your group on the project and analyses, you will need to write the paper on your own. The research paper portion of the project will be worth 100 points. Thus, the two major elements of the semester research project will be worth 150 points, equivalent to one exam or approximately one quarter of your grade.

DESCRIPTION OF THE EXPERIMENT

Introduction

Many ecological theories or principals have been developed after observing species and their interactions with the environment over many years and at many different locations around the world. For instance, the principles of plant succession, niches, the river continuum concept, species-area relationship, and many others were developed through synthesizing knowledge, manipulating systems, and careful observation. Because ecology is a scientific discipline, we treat all of these principles as hypotheses that can be supported or rejected. Thus, it is important that we continue to collect data and test these hypotheses.

Although many ecological principles are well established, others have only been recently developed. One recently developed principle, based upon the *Ecosystem Stress Hypothesis*, is the rural-urban gradient. The rural-urban (or sometimes called the pristine to human-dominated) principle describes how species, communities, and habitats change over the landscape from areas of little or no human influence to areas of high human influence (see Figure 2 in McKinney 2002) and arose out of the urbanizing gradient research of the 1970s (for good reviews of urbanizing gradients see Pickett et al. 2001 and McKinney 2002). This gradient can be defined by such aspects as the amount of impervious surface, anthropogenic noise, automobile traffic, human population size, and building density, to name a few (Table 1). In essence, different studies have used different measures of human influence to investigate how species respond as the human influence measure increases. Notably, some gradient studies have also investigated how species within a specific type of habitat (e.g., a forest) change as the surrounding landscape becomes increasingly urban.

Table 1. Examples of some commonly measured human influence parameters and the range over which they are considered low to high.

Human Influence Parameter Measured	Range of Values (Low to High)	Reference
Human population density (#/km^2)	0 1000	Balmford et al. 2001
Amount of impervious surface	<20% - >50%	McKinney 2002
Percent area covered in pavement	0% - ~40%	Blair 1996
Percent area covered by buildings	0% - ~45%	Blair 1996
# Moving vehicles passing per 15 min	0 - 150	Blair 1996
Percent area covered by trees and shrubs	82% - 12%	Blair 1996

Along this continuum ecologists have hypothesized a number of relationships. These relationships include the decrease of native species richness (i.e., the number of unique types of species that are native to those habitats) and the increase in exotic species richness (i.e., the number of species that have invaded these habitats after European settlement) and the change in community composition (evenness, dominance, etc.) of plant and animal species. Other possible relationships include changes in biomass, ecosystem services (i.e. services provided by nature, such as water or air purification, pollination), and functional groups (i.e. how a species functions within an ecosystem, such as a nitrogen fixer). However, while these relationships have been found in several locations around the world, the pattern is not agreed upon. For instance, two other hypotheses also have been proposed that describe how species change along gradients of human influence. The first is the *Productivity Hypothesis*, in which species richness increases with human influence (e.g., the size of the human population). The second is the *Intermediate Disturbance Hypothesis*, which postulates that the greatest species richness is found at an intermediate level of human influence.

Before you begin the experiment, take a moment to answer three basic questions, which will be fruitful in your work over the course of the semester and help guide your research (both in the field and in the library):

1) Can you draw a single figure that illustrates the three different relationships between diversity and human influence as presented by the three hypotheses (i.e. Ecosystem Stress, Intermediate Disturbance, Productivity)?

2) What are the possible mechanisms (i.e. underlying causes) responsible for generating the relationship observed in each of the hypotheses?

3) What other possible human influences could be measured that might affect species richness and how would we measure them?

The overall goal of this semester long laboratory exercise is to collect data from various positions along the human influence gradient and synthesize it in order to provide support for one of the three hypotheses. To achieve this goal, we will:

- learn to conduct biological inventories in a consistent manner for birds and trees
- share our data among groups and lab sections
- learn to create metadata (i.e. information that describes the data)
- learn to calculate ecological metrics (e.g., Shannon diversity)
- synthesize data using spreadsheets, graphs, and statistics
- learn to find, read, and interpret peer-reviewed scientific articles
- key out species using field guides and dichotomous keys
- keep detailed scientific field notebooks
- write up the outcome of the research in the format of both a poster presentation and a scientific journal article in the style of *Ecology*

Materials and Methods

Study Site(s):

The study sites for this semester will be at five different points along the human influence gradient. These five points are: the UW-Milwaukee field station, Lake Park Golf Course, Riverside Park/Urban Ecology Center, the UWM campus, and neighborhoods around UWM. At each study site individual tree plots and bird point count locations will be randomly determined. Data on human influence is also collected at each location (e.g., percent impervious surface, number of buildings, presence of people, etc.).

Overview of Data Collection and Analysis Methods:

Week	Topic	Assignment
1	Field Trip: Tour of an urban ecosystem	
2	Project overview and literature searches	Literature review exercise (optional)
3	Field Trip: Riverside Park & UEC	Basic bibliography due (optional)
4	Data entry and analysis	
5	All day field trip	Field notebook due
6	Field Trip: TBA	Literature Report Due
7	Sample Processing	
8	Field Trip: TBA	Introduction section of report due
9	Data entry and graphical analysis	
10	Basic statistics	Methods section of lab report due
11	Mapping and GIS	Field notebook due (second review)
13	Poster and report preparation	
14	Presentation of research poster	Final lab report due

Week 1: Touring the local ecosystem (generally urban or human-influenced if near a college or university) to acquaint students with ecological relationships, plants, animals, and the environment in which they live. This is used to get students outdoors and thinking about nature.

Week 2: The semester-long project guidelines are handed out to students and gone over during lab. The rest of the session is dedicated to literature, literature review, and using database search tools in a computer laboratory. Specific aspects include discussing the difference between peer-reviewed literature and gray literature, searching databases using Boolean operators, and where to find both electronic and hard copy journal content. This lab can also be run at a library or by a librarian. A literature exercise was developed as a separate component for grading for this week.

Weeks 2-8: During this four to six week period, students visit different plots along the gradient to conduct biological inventories and record environmental aspects that they can use to assess a human influence gradient. If enough time permits after the inventories in a given lab session, then the data collected can be entered into spreadsheets. Sometime during this six week period (e.g., when inclement weather is present) a lab session is devoted to data entry, quality control and assurance (QA/QC), metadata, and data synthesis in a computer lab. With regard to QA/QC and metadata, there are a number of useful journal articles (e.g., Michener et al. 1997, Michener 2006), numerous books (Michener and Brunt 2000), and several ecological websites related to ecoinformatics that contain detailed descriptions that can be translated into lectures. In addition, when students enter the data, they also add in natural history information, including scientific nomenclature, body mass (animals) or biomass (trees), native or exotic/invasive, etc. that they have obtained through field guides or reputable on-line documents. Reputable sources of on-line documents for natural history or basic biological information included museums, federal agencies, state agencies, and on-line field guides. [see attached document labeled Field Lab 1.doc, which contains the first lab session explanation of biological inventories and types of data to keep in a field notebook]

Weeks 9-10/11: This two week period is devoted to a basic statistical lab (which can also be broken out for a separate exercise if desired) and graphical interpretations. Statistical information includes a short lecture on what the statistics are testing, why they are useful, and how to interpret them. Depending upon the institution and time a third week and component also can be included on integrating GIS into the exercise. Furthermore, if a course is more advanced then the students can work on incorporating additional ecological metrics or data in the database.

Weeks 10/11-13: Lab sessions are devoted to data synthesis and analysis, poster presentations and report preparation. Students tour the science building where many different examples of posters were on hand.

Week 14: Students give oral presentations (in groups) of their posters, and then have one final week to complete their final lab paper.

Questions for Further Thought and Discussion:

The following set of questions can be considered prior to or while conducting the laboratory. In answering the questions, students can be asked to review the literature or seek out additional information. Furthermore, if using these questions early on in the semester they can be graded as a separate component of the laboratory.

1) Why do some species benefit from human influence and others do not?
2) What are the primary metrics ecologists use to define a human-influence gradient?
3) Which species do we know the most about in regards to how they relate to human influence?
4) Which species do we know the least about in regards to how they relate to human influence?
5) What are important biases to consider in the study?

The remaining questions can all be considered after the data have been collected or when the final paper is written.

6) Which of the three hypotheses did you find the most support for based upon your data analysis?
7) How do humans influence native species?
8) Which species benefit from human influence and which do not?
9) What does the preponderance of evidence suggest about how humans influence individual species, populations, and communities?
10) Is a rural-to-urban gradient the same as a pristine-to-human-dominated gradient?
11) What are biases in using the human influence gradient as a framework for the study?
12) How would counting birds at different times of the day change the results?
13) Does the total plant or animal biomass change in relation to the location on the gradient?
14) Based upon our findings, is there any guidance we can offer about the continued development of land around the world or urban sprawl?

References and Links:

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Tools for Assessment of Student Learning Outcomes:

Assessment Components

The overall lab project will be graded based on three separate components: the field notebook, a poster, and a research paper.

Field Notebook

The notebook will be graded twice in order to assess your understanding and progress. Details to be included in the notebook include: a table of contents, page numbers, location of the plots where data is collected, environmental data (e.g., temperature, time of day, sky), andfre9N[(o-3(gical10(in)-5(v)10(e)-3(n)-3(o)ry3(r)10(in))6(f)--3(o)-m)daon ollowing the

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Guidelines for Poster and Group Project Evaluation

The total points a student receives (out of a possible 50 points), is based upon the average of two maj

Student Assessment
Over the course of the semester you and your group have worked together on the lab research project. In order to evaluate your own work and that of the other students, please take a moment to grade everyone in the group, including yourself. A total of 50 points can be given to each student using the general guidelines for grading that follow:
Participation Did the student actively participate in the work over the course of the semester and with the poster? 15 points

Attendance Did the student regularly attend lab or meetings outside of lab? 15 points

Ability to work with group Did the student work well with the group? 10 points

Skills and Contribution Did the student have important ideas or skills to contribute to the project or throughout the semester? 10 points

disbursement to each member of the group (see attached document labeled Student Grading Sheet for Semester Project Poster).

Instructor Assessment
Each poster was assessed based upon the following items:

1. Content 25 points
    a. Title
    b. Main question/idea/hypothesis
    c. Basic methods/approach/instructions
    d. Results and Conclusions
2. Use of Figures and/or Tables 10 points
3. Creativity 10 points
4. Spelling/Grammar/Clarity of writing 5 points

Both the professor and the teaching assistant for the laboratory evaluated each poster
Hence,
the final student grade for the poster is the average of all of his/her group members and both lab instructors (see attached document labeled Group Project Grade Form for the formal rubric laid out above).

Note to instructors posters can be projected on screen without printing them off if time or resources are limited, thereby not allowing stud

Research Paper. The research paper follows the format of a standard scientific article such as the journal *Ecology*, the guidelines for which can be found on the link below. Specifically, the paper will include a title, abstract, introduction, methods, results, discussion, and literature cited. Draft sections of the Introduction and Methods are required and will be evaluated for feedback to students.

The research paper will be done individually and should reflect your own work. Thus, while you can work with members of your group on the project and analyses, you will need to write the paper on your own. The research paper portion of the project will be worth 100 points. Thus, the two major elements of the semester research project will be worth 150 points, equivalent to one exam or approximately one quarter of your grade.

Guidelines for Writing the Research Paper
Preparation of Manuscripts for *Ecology* is as follows, but can also be located at http://esapubs.org/esapubs/preparation.htm

Rubric for the Scientific Paper
(see attached file Rubric for Final Semester Lab Paper for a copy in Word format)
Following the General Guidelines 10 points

Title page 2 points

Abstract 8 points (2 points each section)
- Background or reason
- Main question or hypothesis
- Methods
- Results and discussion

Introduction 10 points (subdivided as follows)
- General background 3 points
- Main question or hypothesis and brief description of what we did 4 points
- Citations or references 3 points

Methods 30 points (7.5 points each section)
- Study Sites or Field Sites
- Field Surveys or Data Collection
- Data Processing or Data Editing
- Data Analysis or Statistical Analysis

Results 20 points (subdivided as follows)
- Main findings 8 points
- Tables and figures 12 points

Discussion 10 points

Literature Cited 10 points

Total__________________(out of 100 possible points)

NOTES TO FACULTY

Comments on Challenges to Anticipate and Solve

1. Interest among all students. Not all students enjoyed this topic of study. The solution to this challenge was to discuss in general terms why it was important to study, to try and have students ask additional subquestions to the main question, and to ask for student input on what they would have preferred to investigate.

2. Semester long project. Most students enjoyed having one large theme to work on all semester, but a handful of students indicated that they would have liked individual labs each week. One of the few solutions to this was to have several separate labs that were not part of the synthetic question. Ultimately, this was the single biggest challenge because students did not like having so much of their time and grade devoted to an overarching synthetic perspective.

3. Poster presentations. Students very much enjoyed creating a poster for their project, but several had little experience with graphical design or software used for poster layouts (e.g., MS PowerPoint). Because students worked in groups, however, peer-to-peer learning generally resolved this issue. Notably, providing a short lecture or demonstration on how to layout posters in PowerPoint at the same as going over general guidelines would be beneficial. One other issue that can arise with posters is the length of time needed to print them out. Students may need several days or a week to have them printed, depending upon location and resources. A simple alternative that I used was to have students project their posters onto a screen just like it was a real printed poster. This solution eliminates printing and the associated time and money associated with it.

4. Data analysis. Most students were able to conduct the statistical analysis either by themselves or at least in their groups. However, some individuals did not understand the output from SPSS. Both the teaching assistants and I worked to resolve this lack of understanding by going over the results with any student that had trouble understanding them. It is important to anticipate that a given percentage of students will have some difficulty in understanding statistics and what the results mean (both numerically and ecologically). Thus, the instructor should be prepared to go over the statistics used and results in some detail with individual students that are struggling.

5. Differences in student knowledge and ability. Although the lab was designed for a 300 level course, students coming into Ecology had a very wide range of backgrounds. For some, the lab was almost too simple (about 10% of students), whereas for about 20% of the students, it was essentially overwhelming. As with any course, trying to find the level and bar to set for students to think and achieve is the main challenge. The solution was to have a number of items turned in to the instructor/TA as a draft and evaluated so that the student could improve the specific item before they were actually graded. In addition, instructors and TAs offered extra lab time and office hours to work with students.

Comments on the Experiment Description

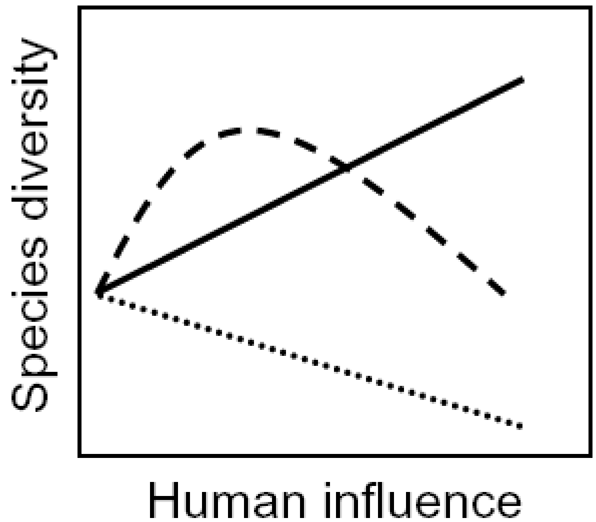

Figure 1. Competing hypotheses relating species diversity and human influence (i.e., population, houses, land cover, etc.): Productivity (solid line), Intermediate Disturbance (dashed line), and Ecosystem Stress (dotted line) from Lepczyk et al. 2008.

Comments on Introducing the Experiment to Your Students:

I introduced the semester project in the second lab by discussing general ecological principles and how we collect data to continue to support or refute them. Then I moved into a discussion of how one current pattern (i.e. the rural-urban gradient) has been shown to have three different relationships (Figure 1). I briefly discuss these three relationships, what they mean, and what some possible explanations may be for the given relationship. While I provided this information on the three relationships when I taught the laboratory, it can easily be modified to make the course more inquiry based. For instance, students could be required to draw out the three general relationships that are described by the hypotheses and illustrated in Figure 1. Following this exercise, students could then conduct a literature review and answer a set of questions (a sample of which are illustrated in the Questions for Further Thought above) that require them to understand the mechanisms responsible for the three different relationships. In addition, students could be asked to find other human influence measures in the literature (e.g., anthropogenic noise, pedestrian traffic) or come up with them in class and discuss how they might relate to species diversity. Depending upon the type of class, different measures of diversity could also be considered. A second component of introducing the lab is to discuss how ecologists assess (i.e. measure) human influence. In the class I taught I explained the general measures of human influence and gave some examples of what either end of the continuum might look like. However, because the human influence gradient is relative, it is important to note how human influence can be measured at each point along the gradient. For instance, the instructor could go over how to count number of cars or people that pass by a site in a given amount of time (similar to Blair 1996). By conducting specific measures of human influence at each site, students can also compare their data with other published results or other classes, if time allows or if multiple years of the experiment are conducted.

Comments on the Data Collection and Analysis Methods Used in the Experiment:

Each week during the field sampling portion of the laboratory, the groups of students would collect information on trees and birds. Depending upon the field site and amount of time needed to collect the data a given group might collect only data on trees or birds for a given lab period, or they might collect information on both. For trees, groups laid out a 10 m by 10 m plot using a compass and measuring tape. The plot should be as close to square as possible. Groups then identified all tree species in the plot to species level (if possible) using the taxonomic keys and field guides provided (if unable to identify in the field, students were able to bring plant material back to campus for further inspection). For each species students recorded the common and scientific names as well as the diameter at breast height (dbh). To measure dbh students found the point on the tree trunk where their sternum would touch if they stood next to it. Then using a tape measure, the students determine the diameter to the nearest mm (if possible). Dbh is

equation.

For bird censuses, point counts were used following the standards established by BBIRD. Under this protocol surveys are carried out for 10 minutes within a 50 m fixed-radius circle. We used a 50 m circle in order to allow comparability among widely different habitat types and to maximize the probability that bird counts reflect vegetation measured at the point. However, all birds detected beyond 50 m should also be recorded to allow total detection of species. All birds were recorded and distinguished by male, female, or unknown for each individual bird detected and distinguish between birds inside and outside of the 50 m radius circle. Once a survey was completed, a group moved to a new location that was a minimum of 200 meters away. The instructor and teaching assistants assisted with bird identifications and counts. One important consideration of the bird counts to note to students and instructors is that the *time of day that birds are counted can greatly influence the bird species present*. Hence, an afternoon count could yield very different compositions of species than an early morning count. To reduce any confounding factors the bird censuses should be conducted at the same time of the day throughout the semester.

After the bird and tree data were collected, the students entered the information into MS Excel spreadsheets in the computer lab (if possible during the end of the laboratory period). All groups followed the same data entry procedure, which included columns for the group name, the field site location, the plot or point count number, common name, species name, and abundance. At the same time students also created a separate spreadsheet page that listed all of the metadata (e.g., descriptions of the field sites, any abbreviations used). After the field data were entered, students added new columns to

biomass for a species, the total mass or biomass of a plot, the native mass or biomass of a plot, the exotic mass or biomass of a plot, the relative abundance of a species in the plot, the richness of all species in a plot, the richness of the native species in a plot, the richness of exotic species in a plot, the Shannon diversity of a plot, and the Shannon evenness of the plot. Bird masses were provided by the instructor from Dunning 1992. Students calculated the biomass for each tree by using allometric equations from Jenkins et al. 2003 that use the dbh estimate and generic tree When all field sites had been entered by all groups, the instructor edited and compiled a master database for trees and a master database for birds from all 16 groups. These databases were placed on the course website so all students could access and use them as needed.

Prior to conducting statistical analyses, the entire class discussed the completed data and where they had been collected. This allowed the students to define the gradient as a relative scheme of plots from fairly pristine to most developed that all students could agree upon (and to which the instructor concurred). In defining the gradient, the students used amount of impervious surface, land use (e.g., residential, commercial, park, etc.), and qualitative views of such factors as anthropogenic noise, traffic, and presence of people. Once the gradient was finalized, students coded the gradient from 1 to 6, with the former being the most pristine, thereby allowing for regression analysis. In order to help guide students on the regression exercise I used a graphic similar to Figure 1 and discussed which type of model would describe each of the three lines with each lab section during the day of analysis. Specifically, we discussed how a linear model could support either the Productivity or Ecosystem Stress Hypothesis as well as how a quadratic model could support any of the three hypotheses, depending upon the Then, within groups, the students converted the Excel data into SPSS data and conducted linear and quadratic regressions of the data. For instance, students investigated how total species richness, native species richness, and exotic species richness changed over the gradient. After the regressions were run, students compared whether a linear or quadratic model was better by comparing adjusted r^2 values, p-values and figures of the linear and quadratic models. In summarizing all of the results, students compared the linear and quadratic models, as well as if any model was significant.

The basic design of the analysis is set-up to allow students to compare whether a relationship exists between the diversity measures and the human influence measures. If a relationship does exist according to the statistical results, the students need to understand (often through graphing the result in conjunction with the formal statistics) and interpret which hypothesis is supported. Because the three hypotheses are essentially an increasing, decreasing, or negative parabolic relationship, it is fairly straightforward for students to interpret the results to each hypothesis. If a number of different taxa or diversity measures are being investigated, then it is important to have students consider which hypothesis has the most or predominate amount of support.

Data collection for this lab can vary greatly, depending upon what taxa the instructor or students are interested in studying. The most important portions were to describe how to lay out plots, conduct biological inventories, enter data into Excel, and work with computer software. In addition, it would be beneficial to discuss aspects of quality assurance and quality control (QA/QC) and metadata early on in the semester (if not even before field work begins) in order to give students a broader appreciation of the value and importance of their data.

Depending upon the course and institution, the laboratory Methods and Materials can be altered to be more inquiry based than presented. For instance, rather than layout all of the study sites and specific types of data collected, students could be asked to determine what type of data they are going to collect, how they would conduct the specific measurements, how many sites they should collect from, and why these are important aspects. Such inquiry could lead to discussions of experimental design, sample size, replication, sampling methodology, and field methods.

Formulas Used in the Laboratory

Species Richness: the sum of all unique species in a given plot.

Relative Abundance: the proportion (p_i) of a species abundance relative to the total abundance of all species.

Shannon Diversity (H'): H' = - $_i$ln(p_i), where H' = the Shannon Diversity index, p_i = the proportion of the ith species, and ln = natural log. The summation is for all species in a given grouping.

Shannon Evenness (J'): J' = H'/ln(S), where S = the number of unique species (i.e., richness)

Tree biomass: *bm* = *Exp* $_0$ $_1$ln*dbh*); where *bm* = total aboveground biomass (kg dry weight) for trees 2.5 cm *dbh* and larger, *dbh* = diameter at breast height (cm), Exp = exponential function, and ln = natural log. $_0$ $_1$ can be found by tree groupings in Jenkins et al. 2003.

Comments on Questions for Further Thought:

1. How do humans influence native species?

2. Depending upon what students find, it could certainly be positive, intermediate, or negative. In the case of my course, the birds generally supported the ecosystem stress hypothesis as native species declined and exotic species increased. However, trees did show more variance.

3. Which species benefit from human influence and which do not?

4. Depends upon the location, but it is interesting for students to consider which factors may lead to a species benefiting from influence. This can lead to many other questions about synanthropy, species endangerment, etc.

5. What does the preponderance of evidence suggest about how humans influence individual species, populations, and communities?

6. Likely to indicate that humans are detrimental, but again will depend upon how gradient is laid out, species sampled, etc.

7. Is a rural-to-urban gradient the same as a pristine-to-human dominated gradient?

8. This question depends upon the depth to which students have reviewed the topic in the literature as well as how much they may have thought about the project. Within my class several students were able to note that we can measure human influences in many different ways and they suggested this might influence the outcome of the gradient. However, students could have gained a broader understanding of this question if it was posed as an open discussion topic at the end of the semester.

9. Does the total plant or animal biomass change in relation to the location on the gradient? To answer this question the students needed to look through the results of their regression models. During the analysis portion of the lab, students calculated linear and quadratic regressions of total biomass, native biomass, and exotic biomass form trees and birds separately. All groups found that <u>total</u> bird biomass decreased significantly over the gradient, but that <u>total</u> tree biomass showed no significant trend (it did however decrease non-significantly).One misconception with understanding these changes along the gradient were if they were significant or not (i.e. the pattern suggested a relationship, but the statistical result indicated no significant relationship). Other misconceptions included remembering the differences between native and exotic species.

10. Based upon our findings, is there any guidance we an offer about the continued development of land around the world or urban sprawl?

11. A major finding of the study was that native species and total species richness, diversity, evenness, and biomass decreased with increasing levels of human influence for one or both taxonomic groups. Tree and birds did differ from one another, but the preponderance of evidence suggested that human land development was not beneficial to most species or biodiversity. Generally, the result found by students did not lead to any misconceptions. If anything it solidified what a number had suspected about the negative ramifications of urbanization or land development.

Comments on the Assessment of Student Learning Outcomes:

I used three major pieces of assessment for this lab, which ultimately I believe may have been too few. Breaking out a few more aspects for separate grades or more in-depth consideration would likely have been beneficial for students. Similarly, spreading out the assessments over a wider portion of the semester, instead of coming predominately at the end, would have been beneficial for students. Comments on each assessment aspect are listed below:

Field Notebook. The field notebook was a very positive experience for all students. Many liked using Rite in the Rain books (especially when it did rain!) and learning to record field information. By grading the notebooks after two field labs, students were able to vastly improve their skills and continued to hone their note taking skills. Furthermore, the teaching assistants and I were able to look at individual improvement over several field trips. In retrospect I would have graded the notebooks three times instead of twice. In addition, while students did receive a lecture and handout on biological monitoring and field data collection, I would provide either photocopies or add

Poster. Students found the poster presentation to be the best of the three assessment tools. They enjoyed learning how to use MS PowerPoint or MS FrontPage to create a visual document and how their vision compared to other groups. Main issues that I dealt with were showing students how to tell a story visually while also including the relevant content and figures. Students also appreciated that their independent grades were an amalgam of their peers and the instructors, thus slightly limiting the ability of any one person from sinking their overall grade. Although I did not evaluate a draft version of

grade dispersion.

Paper. The synthetic paper in the style of *Ecology* was the main component of the course and ultimately was both a very positive tool and also a very difficult one. Successful students put a great deal of time into their work and produced papers that were written in a scientific style, included a number of additional citations, and looked like draft papers from an MS thesis. On the other hand, for students that were weak writers, the paper was very challenging and a source of great frustration. Having students do drafts of other sections and perhaps even critiquing each others (an opportunity to talk about peer review as well) would have been useful. Similarly, offering students the opportunity to revise a section like the Methodology or Introduction several times would have been beneficial to a handful of students. Finally, I used a system of grading the draft sections of the Introduction and Methods that was simply a check minus, check, or check plus to indicate the level that a student had achieved. Upon reflection I would have the draft sections of the paper count either as a completely separate grade or as a percent of the final paper grade.

Comments on Formative Evaluation of this Experiment:

Because this particular laboratory requires most, if not all semester, the students have a variety of thoughts on its value. After running this laboratory for the first time I handed out an evaluation form (a copy of this evaluation can be found under the download

In general, the overall majority (61%) of students liked the approach of one long project and enjoyed being in the field doing real science. Similarly, ~71% of the students would recommend this laboratory to others in the future. While there were legitimate criticisms of certain aspects of the lab (e.g., amount of time to get to a field site), most of what students disliked about the lab are common among any lab exercise or class. For instance, many students disliked analyzing the data, having to collect multiple samples, and working in groups.

Based upon this evaluation, students had the following thoughts to the questions:

1. Did you like doing one large semester project?
   YES = 61.1% (44/72) vs. NO = 25%
   (18/72), with the remainder being undecided or not answering. Interestingly, half of the NO students (n = 9) were all from the first lab session, which began at 8:00 AM and was the last choice lab section every year according to previous instructors. Hence, it is likely a portion of this group would have been dissatisfied with any lab option.

2. What did you like **best** about the lab?
   The most common answer was working outside/field trips, followed by such reasons as: that it was a real world lab/real scientific project, collecting field data (hands-on), the uniqueness of the semester long approach, working in groups, working on an interesting topic, topics were well explained, the interactive nature of lab sessions, and not having quizzes.

3. What did you like **least** about the lab?
   Common answers included: data entry and analysis, having a lot of work due at the end of the semester, group project, not understanding the labs or the overall goal of the project, having to conduct the same type of inventories at multiple locations (repetitive), boring and filled with busywork, not having enough time, the research paper, too many field trips (being outside), too many separate tasks, the lack of many lectures in lab, using new software (i.e. MS Excel, SPSS) and computers, too much work for a 300 level class.

4. Question 4 contained 15 subquestions, with response options ranging from Greatly Disliked (1) to Greatly Liked (5). The following are mean responses based on 72 responses as follows:

    4a. First week field trip around Milwaukee: 3.86
    4b. Weekday field trips (UEC, Campus, etc.): 4.32
    4c. Weekend field trip to UWM Field Station: 3.85
    4d. Learning to count birds: 3.64
    4e. Learning to count trees: 3.71
    4h. Learning to use Excel: 3.60
    4i. Learning to enter metadata: 3.24
    4j. Learning to conduct scientific literature review: 3.15
    4k. Learning to use a statistics program: 3.24
    4l. Learning new types of software: 3.50
    4m. Learning to make a poster presentation: 3.49
    4n. Learning to use a field notebook: 3.78
    4o. Learning to write a scientific paper: 3.34

5. Would you recommend this laboratory to other students?
    YES = 70.8% (51/72) NO = 20.8% (15/72) NO OPINION = 8.3% (6/72)

Overall, most students found each major aspect of the course to be a positive experience. However, considering these comments, there are aspects of the laboratory that would benefit from modification in the future. First, splitting the graded components up over the semester would help some students from feeling so overwhelmed at the end. Second, spend a bit more time on explaining the need for replication and the value in having many people collect data. Third, I would integrate the literature review component into the lab and have them use the literature to more depth.

Comments on Translating the Activity to Other Institutional Scales or Locations:

(1) The lab is easily conducted at large or small institutions and can be expanded or reduced by an instructor to meet their course needs very easily. Essentially, many aspects of the lab can be parceled out into smaller components that answer separate questions and have graded components or more aspects can be added. For instance, the gradient paradigm presented here can be simplified by an instructor or even used with preexisting data collected from all or part of the gradient if time does not allow for a full semester project. In particular, the data provided with this laboratory can be used over the course of one or two lab sections to answer several questions if an instructor is so interested.

(2) The lab can easily be conducted in any location around the world where there is a human influence gradient. Similarly, the lab can be run using many different taxa, although they should be terrestrial species. Finally, the lab can be run at different times of the year as long as the instructor is aware of the types of species present in a given

season. However, winter is probably the least opportune time to conduct the lab for both students and the species that can be censused.

(3) The only limitation for physical disability is dependent upon the field location. In regards to learning disabilities, this exercise may be more challenging for students that have short attention spans as it is a long term project with benchmarks.

(4) This lab can be simplified and/or shortened to teach to pre college levels by removing some of the multiple sampling within sites and/or focusing on only a single taxonomic group. If used in a pre college level, the laboratory may require that the instructor spend additional time to review the background literature in order to fully understand the scope of the questions. Essentially the instructor would need to assess the specific class that he or she wishes to use this laboratory for and adjust it accordingly.

(5) Several aspects of the
guidelines for laboratory exercises. For instance, institutions vary on whether or not they allow students to drive themselves to a field site for a class requirement.

(6) Conducting a laboratory of this scale certainly benefits from having a teaching assistant. However, it should be noted that this ultimately depends upon how many students are present in a laboratory section, how much travel would be necessary, and how in-depth the instructor would like to make the laboratory.

STUDENT DATA PAGE

Student Products

In order to exemplify the semester laboratory and provide material for shortened laboratories, the following items have been included:

- Cleaned and Compiled Tree and Bird Data for Processing
  (Urban Gradient Tree and Bird Data.xls)
  [XLS] (82.5 KB)

- Solved Data for Semester Lab Project
  (Solved Data for Semester Lab Project.xls)
  [XLS] (98.5 KB)

- Examples of Final Student Posters
  (Final Student Poster Examples PDFs 1-4)
  Example 1 [PDF] (1.02 MB)
  Example 2 [PDF] (132 KB)
  Example 3 [PDF] (88.8 KB)
  Example 4 [PDF] (4.05 MB)

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